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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM. 24

CALCULATION OF WING SPARS.

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By

Julius Ratzersdorfer.

Translated from
"Zeitschrift für Flugtechnik und Motorluftschiffahrt,"
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CALCULATION OF WING SPARS.*

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In the October 15, 1919, number of "Zeitschrift für Flugtechnik und Motorluftschiffahrt," Mr. Müller-Breslau published, in connection with an earlier article by himself and previous articles by Mr. Pröll, a simplified method for the approximate determination of flexures and the maximum bay moments for a one - bay spar over an opening.

In the "Osterr. Flugzeitschrift" (May-June, 1919), I gave a general method for calculating wing spars. The spar passes over as many openings as desired (corresponding to practical experience) bringing various longitudinal stresses into play.** The calculation has now been simplified, so that the exact method can be carried out more quickly and clearly than the approximate method. I will demonstrate this for the special case taken up by Mr. Pröll, and, in the October number, by Mr. Müller-Breslau.

The spar lies over an opening s (Fig. 1) and is compressed axially by S and is uniformly loaded transversely with g per unit of length. The static moments are designated by M_A and M_B. Since only a longitudinal stress is present in the opening, the fundamental assumption of my treatise on the direction of the

* Taken from "Zeitschrift fur Flugtechnik und Motorluftschiffahrt," April 30, 1920, p.102.

** See further: Ratzersdorfer "Berechnung axial-und gleichförmig querbelasteter Träger," "Zeitschrift des Osterr. Ing. - und Arch.-Vereines," 1919. Full length spars, with any desired number of openings, subjected to longitudinal and transverse stresses. "Eisenbau" (Iron Construction" 1919.

longitudinal stress on the division line of two fields is here of no consequence.

1. <u>Moments in Polar Coordinates</u>.

We first calculate the expressions $k^2 = \frac{EJ}{S}$, gk^2 and $\alpha = \frac{S}{k}$. E is the modulus of elasticity of the spar material, J the supporting moment of the surface of the cross-section with reference to the horizontal weight axis, whereby this is assumed to be a principal axis. We then construct the angle α (Fig. 2) and the gk^2 circle with the center o (the pole) at the apex of the angle. From the end points a and b we construct the static moments M_A and M_B, whereby positive outward and negative inward moments are formed ($a\,a_1 = M_A$, $b\,b_1 = M_B$). The circle through the points a_1, b_1 and o and the gk^2 circle inclose the moment surfaces. Each moment is here drawn radially to o. The bending moment in the cross-section of Fig. 1 is given in the polar diagram by the line $x_1\,x_2$, which, with o_a forms the angle $\frac{x}{k}$. It is evident that the maximum bay moment lies on the diameter o_c.

2. <u>Flexure</u>.

At the points of support (Fig. 3) we lay out the moments M_A and M_B from a horizontal (for instance, negative upward) and connect the ends of these lines by a "closing line." From this closing line we transform the line of moments, obtained by the polar diagram, into right-angled coordinates, so that the moment for the cross-section x is given by $m_1\,m_3$. Then we draw the parabola $\frac{g\,s^2}{8}$ through the points A and B, so that $m\,m_2$ de= notes the moment of flexure caused by the transverse loads for the "simple girder" AB at the point x. The line m_2m_3 then gives the s-fold value of the flexure in the cross-section x, the drawing being to the scale $\frac{1}{s}$. The unit is obtained directly from the unit of moment.

(Translated from "Zeitschrift fur Flugtechnik und Motorluftschiffahrt," April 30, 1920, by National Advisory Committee for Aeronautics.)

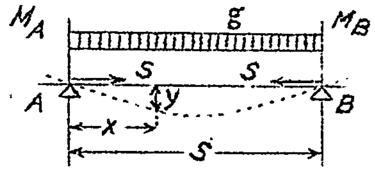

Fig. 1.

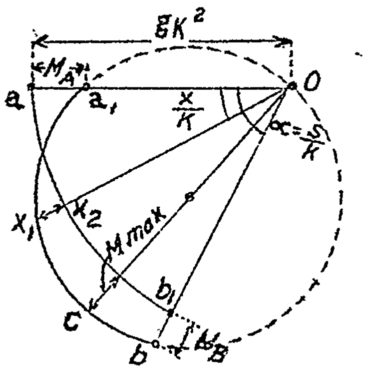

Fig. 2.

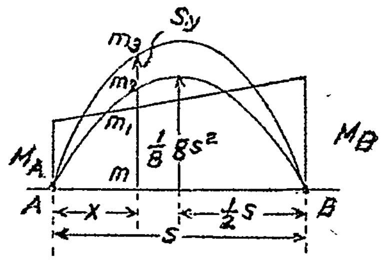

Fig. 3.